April 11, 1967 A. E. POWELL 3,314,044

FEMALE ELECTRICAL CONNECTORS

Filed Dec. 16, 1964

Fig. 1.

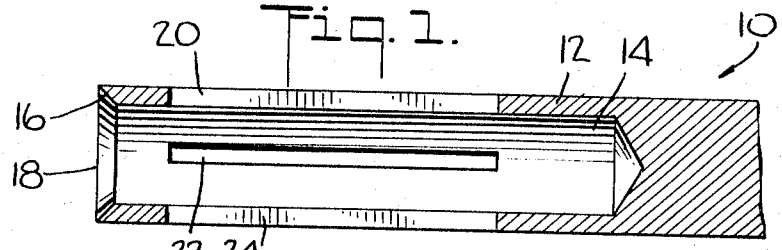


Fig. 2.

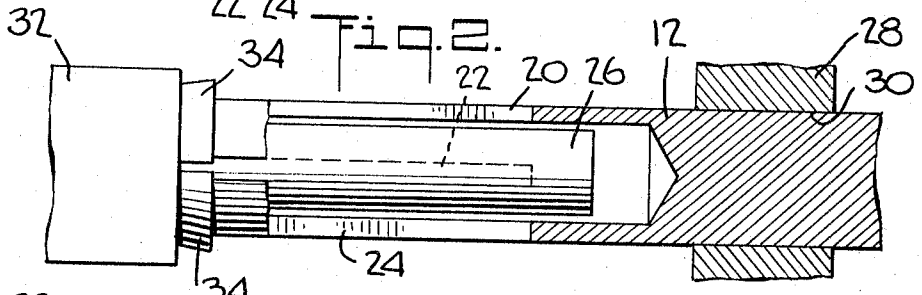


Fig. 3.

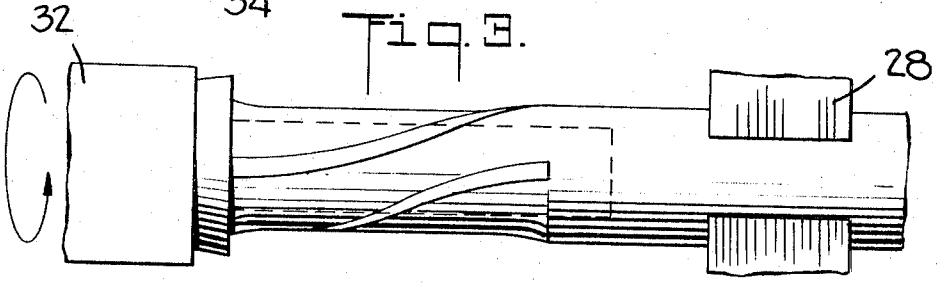


Fig. 4.

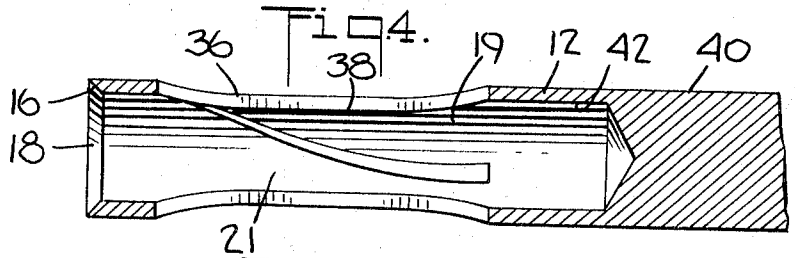


Fig. 5.

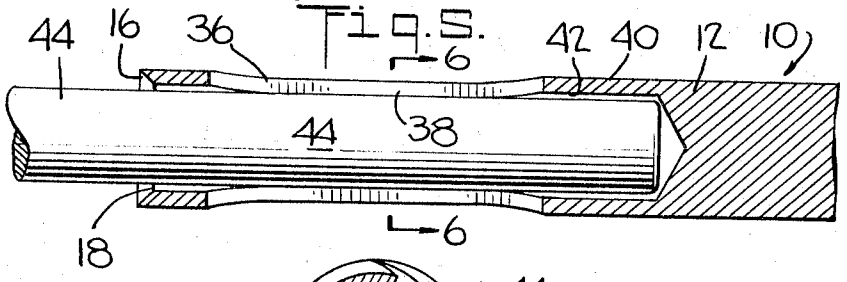
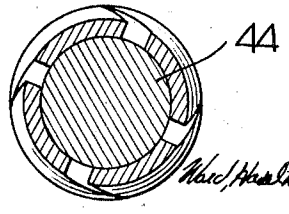


Fig. 6.



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United States Patent Office 3,314,044 Patented Apr. 11, 1967

3,314,044

FEMALE ELECTRICAL CONNECTORS

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Filed Dec. 16, 1964, Ser. No. 418,733
2 Claims. (Cl. 339—256)

This invention relates to contacts and more particularly to a female contact member for receiving a corresponding mating male member.

Contacts embodying the present concept are particularly adapted, among other possible uses, for use in conjunction with a male contact member to establish a separable contact in an electrical circuit, and for use in coaxial connections where a constant cross-sectional configuration is desirable in order to maintain constant ratios of internal to external diameters to provide constant impedance. The connection according to this invention is also adapted for other devices whereever low contact resistance is desirable.

Heretofore, the usual female contact member used in conjunction with a male contact member to establish a separable contact comprised a rod having an internal bore extending inwardly from one end thereof. The rod was then slotted inwardly from the same end forming a bifurcated head, the two ends being slightly crimped to frictionally receive a mating male member. The disadvantage of such a contact resides in the fact that the only portion of the female member in contact with the male member is the tips of the ends of the bifurcated head. Thus, the mechanical gripping action is not very satisfactory and the electrical resistance is high.

A feature of this invention resides in the provision of a new and improved female contact member which has a relatively low electrical resistance, which may be fabricated from inexpensive materials, which provides good gripping action, and which provides a relatively large contact area with a mating male contact member.

Another feature of this invention is the provision of a new and improved female contact member which readily receives the mating male member but resists the withdrawal of the male member, which has superior axial alignment characteristics, which resists injury or damage due to careless or improper handling, which has a long life, and which is compact, convenient, practical and inexpensive to manufacture.

In essence, the present invention contemplates the provision of a female contact member for receiving a corresponding mating male member wherein the female member comprises an elongated member having a substantially centrally disposed longitudinally extending bore commencing from one end thereof. There are a plurality of helically twisted or torsional grip members which serve as a portion of the elongated member, this portion being disposed coaxially with respect to the longitudinally extending bore and spaced inwardly of the end of the elongated member. The grip members may have substantially parallel edges one with respect to the other which define a like plurality of longitudinally extending slots. The internal perimeter of the grip member is reduced prior to the insertion of the male member. Subsequent to the insertion of the male member, the female member expands to substantially the same dimensions as the remainder of the elongated member.

In one form of the invention the female contact member for receiving a corresponding mating male member comprises a rod or tubular element having a central bore extending inwardly a substantial distance from one end thereof to receive said male member. A portion of the tubular member, spaced inwardly with respect to the end thereof, is provided with a plurality of helically twisted, radially resilient, grip members formed by longitudinally slotting and axially twisting the tubular member whereby upon insertion the male member is releasably retained in contact position.

The invention in another form thereof comprises a method of manufacturing a female contact member comprising taking a tubular member, longitudinally slotting a portion of said member, fixedly gripping said tubular member at a first position while simultaneously twisting said member at a second position spaced from said first position along the longitudinal axis of said member, thereby "necking down" said tubular member for releasably retaining a male member in contact position upon insertion. The term "neck down" as used herein means to reduce the diameter of the rod or tubular member along a portion of the longitudinal length.

There has thus been outlined rather broadly the more important features of the invention in order that the detailed description thereof that follows may be better understood, and in order that the present contribution to the art may be better appreciated. There are, of course, additional features of the invention that will be described hereinafter and which will form the subject of the claims appended hereto. Those skilled in the art will appreciate that the conception on which this disclosure is based may readily be utilized as a basis for the designing of other structures for carrying out the several purposes of the invention. It is important, therefore, that the claims be regarded as including such equivalent constructions as do not depart from the spirit and scope of the invention. A specific embodiment of the invention has been chosen for purposes of illustration and description, and is shown in the accompanying drawings, forming a part of the specification, wherein:

FIG. 1 is a longitudinal sectional view of a tubular member after completing the initial steps employed in the fabrication of a contact member in accordance with the concept of the invetnion;

FIG. 2 is a side elevation, partially in longitudinal section, showing a vise and rotary collet gripping the contact member during the fabrication of a female contact member;

FIG. 3 is a side elevation of the female contact, mandrel, member, vise and rotary collet subsequent to the twisting of the member;

FIG. 4 is a longitudinal sectional view of the female contact member constructed in accordance with the concept of this invention;

FIG. 5 is the female contact member of FIG. 4 in engagement with a corresponding mating male member; and

FIG. 6 is a transverse sectional view taken along the line 6—6 of FIG. 5.

In the illustrated embodiment of the invention, the female contact member designated generally at **10** (FIG. 1) comprises a tubular member **12** which may be fabricated from a solid bar by means of drilling a centrally disposed longitudinally extending bore **14** therein. It

will be appreciated that the tubular member **12** may be manufactured using brass or other suitable inexpensive copper alloy as compared to the materials required by the prior art devices which employed Phosphor bronze, beryllium copper, for example. Not only are such materials less expensive, but they are also easier to machine and work as compared to materials required by the prior art. The tube **12** is provided with a chamfer **16** at the entrance thereof **18** in order to guide the entry of a male probe to be used with this contact. A plurality of longitudinally extending slots **20**, **22** and **24** (FIG. 1) are disposed in radially spaced relationship one with respect to the other about the tubular member **12**, slots being milled or sawed in the wall of the tube **12**, as desired.

As best seen in FIG. 2, a rod or mandrel **26** having a diameter slightly smaller than the mating male contact to be used, is inserted in the tubular member **12** at least as far as the ends of the slots **20**, **22** and **24**. The tubular member **12** is held or gripped by a vise **28** as at **30** (FIG. 2). Still referring to FIG. 2, the end of the tubular member **12** is gripped by jaws **34** of a rotary collet **32**.

As best seen in FIG. 3, the collet **32** is rotated while the vise member **28** is retained in a stationary or fixed position. This gives the elongated slots **20**, **22** and **24** a helical or spiral-like configuration. The portion of the tubular member **12** adjacent the slots **20**, **22** and **24** necks-down until the inside diameter of this portion contacts the mandrel **26** and is thereby limited from further necking-down. In effect the mandrel **26** during the twisting operation of the collet **32** tends to direct the tubular member to conform to the outside diameter thereof and to form an elongated neck-down portion extending substantially the length of the slots **20**, **22** and **24**. Thence the mandrel **26** is removed from the tubular member **12**, the collet **32** is removed therefrom and the vise **28** is released. The female contact member **10** is then in its final form and has the appearance as shown in FIG. 4.

Referring to FIG. 4, the portions of the tubular member **12** adjacent the slots **20**, **22** and **24** are coiled gripping members **19** and **21** as shown. It will be appreciated that the gripping members **19** and **21** have a substantially helical configuration and are torsionally deflected. Also, it is noted that the necked-down portion **36** is an elongated section having a substantially uniform internal diameter **38**.

In order to make an electrical connection or contact a male contact **44** (FIG. 5) is inserted through the entrance **18** into the female contact **10**. It is noted that the chamfer **16** helps to align the male member **44** for insertion when contact is to be made. It will further be appreciated that the axial forces required to insert the male member are substantially less than the forces required to retract the male member. This is due to the fact that during insertion the necked-down portion **36** of the tubular member **12** is subjected to compression, one force acting towards the right as viewed in FIG. 5 by the male member **44** and the second force acting towards the left as viewed in FIG. 5 by the female member **10**. These two forces tend to spread or open the slots **20**, **22** and **24** and thereby increase the diameter **38** of the necked-down portion **36**.

On the other hand when the male member **44** is being retracted or withdrawn from the female member **10**, the necked-down portion **36** is under tension and hence this portion tends to reduce in diameter and thereby grip the male member tighter. Moreover, the gripping members **19** and **21** are torsionally deflected and the internal surfaces tend to grip the male member **44** with a twisting-like grip. It will be appreciated that when the male member **44** is fully inserted in the female member **10** the external diameter **36** of the grip member portion **19**, **21** is substantially equal to the diameter **40** of the tubular member prevailing before the necking-down or twisting operation. This provides a substantially constant cross-section, and here, provides a substantially constant impedance.

Particular attention is directed to the large elongated contact surface between the male member **44** and the female member **10**. This factor is of particular significance not only for mechanical interlocking purposes but also in providing a contact of low electrical resistance. The following table tabulates the physical dimensions of four different samples of female contact members constructed in accordance with the concept of this invention. It will be appreciated that these contacts are given for illustrative purposes and not for purposes of limitation.

TABLE

	Example			
	1	2	3	4
Tubular Member, Outside Dia., Mils	66	36	36	20
Tubular Member, Inside Dia., Mils	50	20	25	12
Tubular Member, Perimeter, Mils	207	113	113	62.8
Slot, Number of	6	4	3	3
Slot, Width, Mils	10	6	5	4
Slot, Length, Mils	135	135	125	90
Total Width, All Slots, Mils	60	24	15	12
Ratio, Total Width of all Slots/Tubular Member Perimeter	.29	.212	.133	.191
Approximate Angle of Twist, Degrees	120	120	120	120
Material	Brass	Brass	Brass	Brass

In general the slot should be as long as possible because the longer the slot the less torsion is required to twist the tubular member. The relationship between the slot width, the number of slots, the perimeter of the tubular member and the angle of twist is of critical concern. The minimum twist of the arcuate member is a distance sufficient to neck-down the tubular member to an internal diameter less than the internal diameter of the outside diameter of the mating male member. The maximum twist of the tubular member is an arcuate distance such that the tubular member necks down to the point where the slots are substantially closed. If the tubular member is twisted beyond this point the tension stress would tend to break the member. Preferably the angle of twist is of the order of about 120 degrees. The range of the ratio of the total width of all slots divided by the tubular member perimeter is from about 12 to about 40 percent and preferably is between about 13 percent and about 29 percent.

Referring in particular to Example No. 3 in the above table, the tubular member was twisted against a mandrel having a diameter of 197 mils. It was tested with a male contact having an outside diameter of 20.5 mils and a length of 105 mils. This contact showed a resistance of 0.0027 ohm, which compares to a resistance of 0.006 ohm for a similar bifurcated contact of the prior art, said prior art contact had the following dimensions: external diameter 36 mils, internal bore prior to crimping 25 mils, slot 135 mils long extending from the open end of the contact, the width of the slot 10 mils, crimped so that the two free ends just touched. It is noted that the prior art contact was manufactured from Phosphor bronze, and the contact according to this invention was manufactured from brass. The same male contact member was used with the prior art device as was used in conjunction with Example 3 of the device according to this invention. It will be further appreciated that the resistance of the device according to the present invention had a variation of less than 3 percent after 200 insertions of the male member.

It will thus be seen that the present invention does indeed provide an improved female contact member and a method of manufacturing same.

Although a particular embodiment of the invention is herein disclosed for purposes of explanation, modifications thereof after study of this specification, will be ap-

parent to those skilled in the art to which the invention pertains. Reference should accordingly be had to the appended claims in determining the scope of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. A female electrical contact member for receiving a corresponding mating male electrical member, said female member comprising an elongated member having a substantially centrally disposed longitudinally extending bore commencing from one end thereof, said elongated member having an elongated necked-down tubular portion spaced inwardly from said one end, said portion having a substantially uniform internal diameter less than the diameter of said bore, said portion of said elongated member being provided with a plurality of resilient torsional gripping members separated by slots, said gripping members extend substantially the length of said portion and which are helically twisted through an angle of about 120 degrees, the summation of the slot width being a distance of between about 13 percent and about 29 percent of the perimeter of said elongated member prior to twisting, said slots being substantially closed subsequent to twisting, whereby said gripping members exert a combination radial and torsional force upon the male member when it is in its inserted position.

2. A method of manufacturing a female electrical contact member for receiving a corresponding mating male electrical member, said method comprising taking an elongated member, forming an elongated centrally disposed longitudinally extending bore commencing from one end thereof, removing about 13 percent to about 29 percent of a perimeter portion of said member in the form of a plurality of spaced longitudinal slots commencing inwardly of the end thereof, inserting a mandrel having an outside diameter slightly smaller than said bore into said elongated member to a position adjacent said slots, torsionally deflecting said member through an angle of about 120 degrees to have the slotted portion conform to the outside diameter of said mandrel to form an elongated necked-down tubular portion having a substantially uniform internal diameter less than the diameter of said bore, continuing said deflecting until said tubular portion extends to a longitudinal length greater than 50 percent of the length of said slots, and removing said mandrel from said elongated member.

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